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(54) **LIQUID EJECTION HEAD WITH PLURALITY OF CHANNELS FOR SUPPLYING LIQUID TO SUPPORT PORT**

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B41J 2/175 (2006.01)
B41J 2/14 (2006.01)
B41J 2/19 (2006.01)

(52) **U.S. Cl.**

CPC . ***B41J 2/1433*** (2013.01); ***B41J 2/19*** (2013.01)

(58) **Field of Classification Search**

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USPC 347/65, 66, 67, 85, 86, 87
See application file for complete search history.

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(57) **ABSTRACT**

A liquid ejection head includes an element substrate and a support member. The element substrate includes an ejection orifice row, and a supply port. The support member includes a first flow path for supplying a liquid from a liquid supply source to the supply port. The first flow path includes a plurality of channels for supplying liquid to the supply port. At least one of the plurality of channels has a shape in which a cross section that intersects with a flow direction Y of the liquid increases from an upstream side to a downstream side with respect to the direction in which the liquid is supplied.

8 Claims, 10 Drawing Sheets

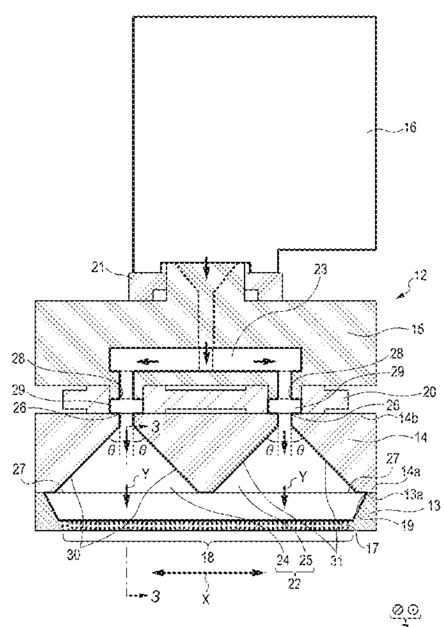


FIG. 1A

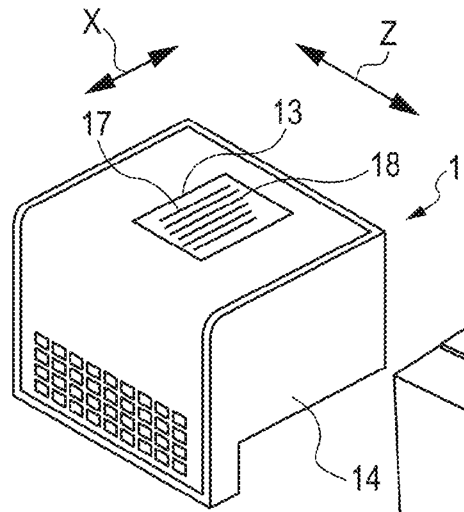


FIG. 1C

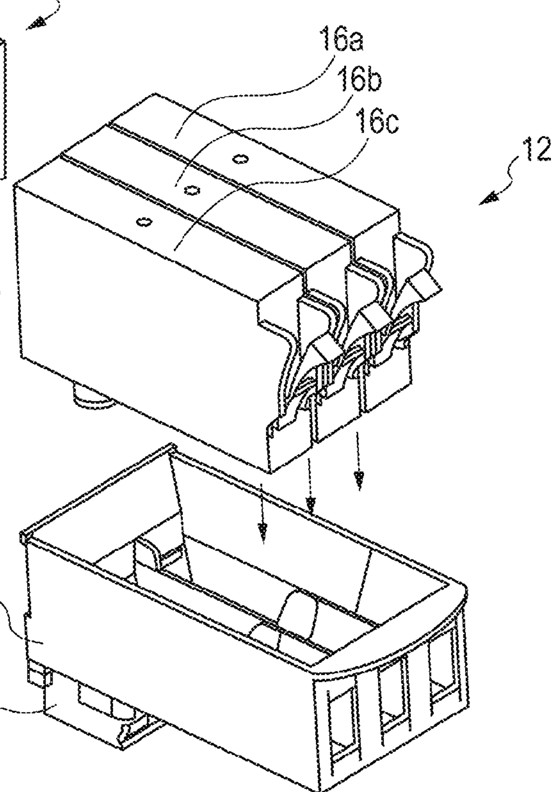


FIG. 1B

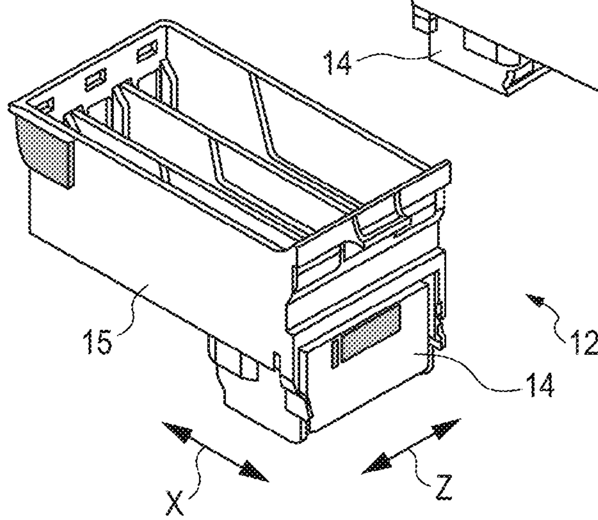


FIG. 2

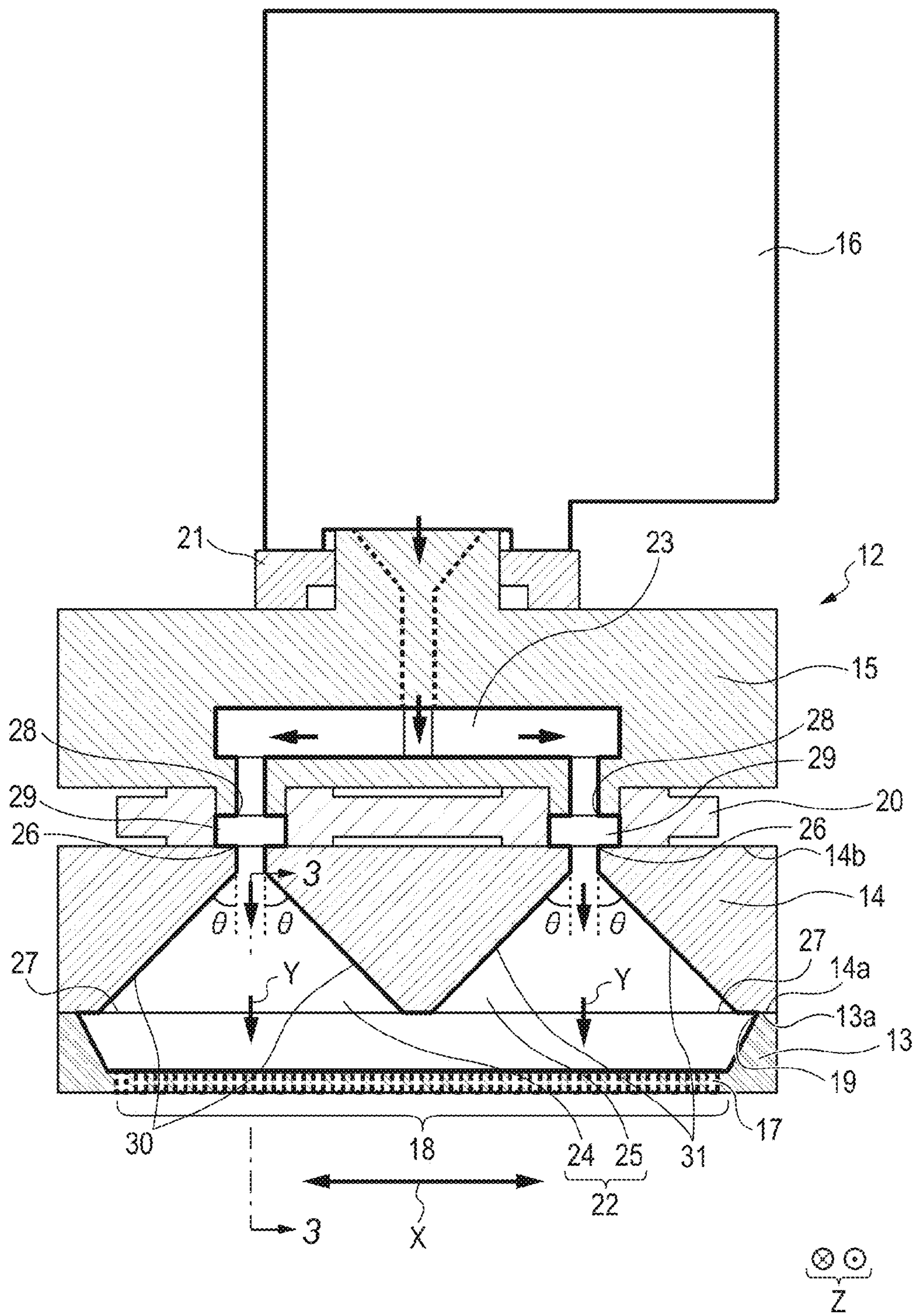

16
21
23
12
15
28
28
29
29
20
26
26
14b
3
14
θ
θ
θ
θ
27
27
14a
Y
Y
13a
13
19
30
18
24
25
31
17
22
X
3
Z

FIG. 3

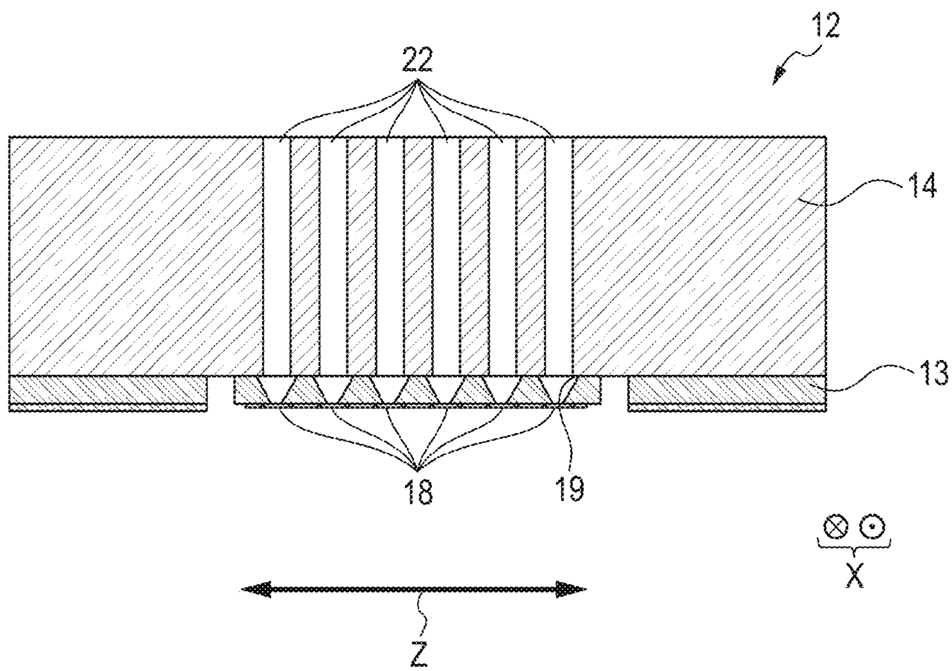


FIG. 4

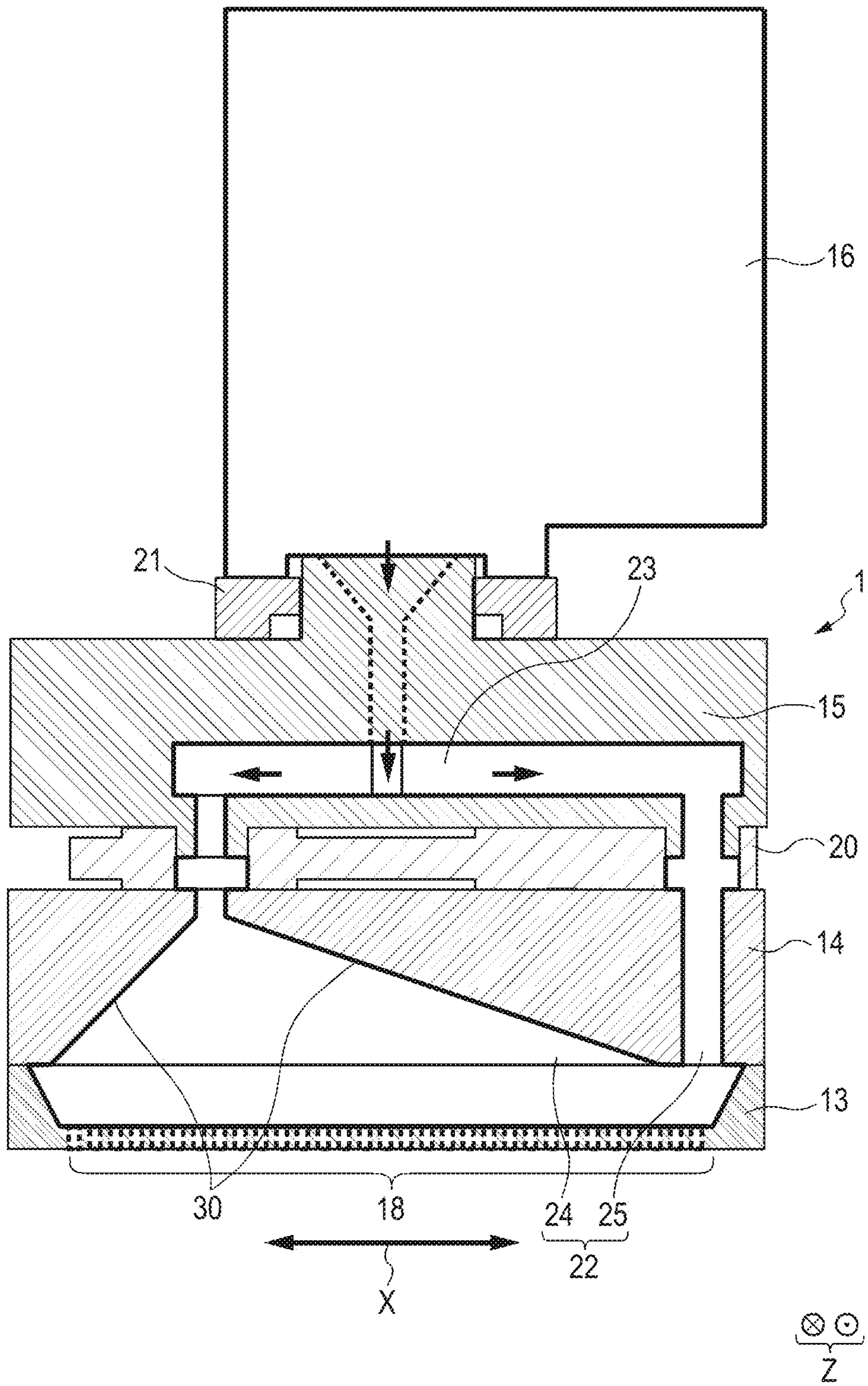


FIG. 5

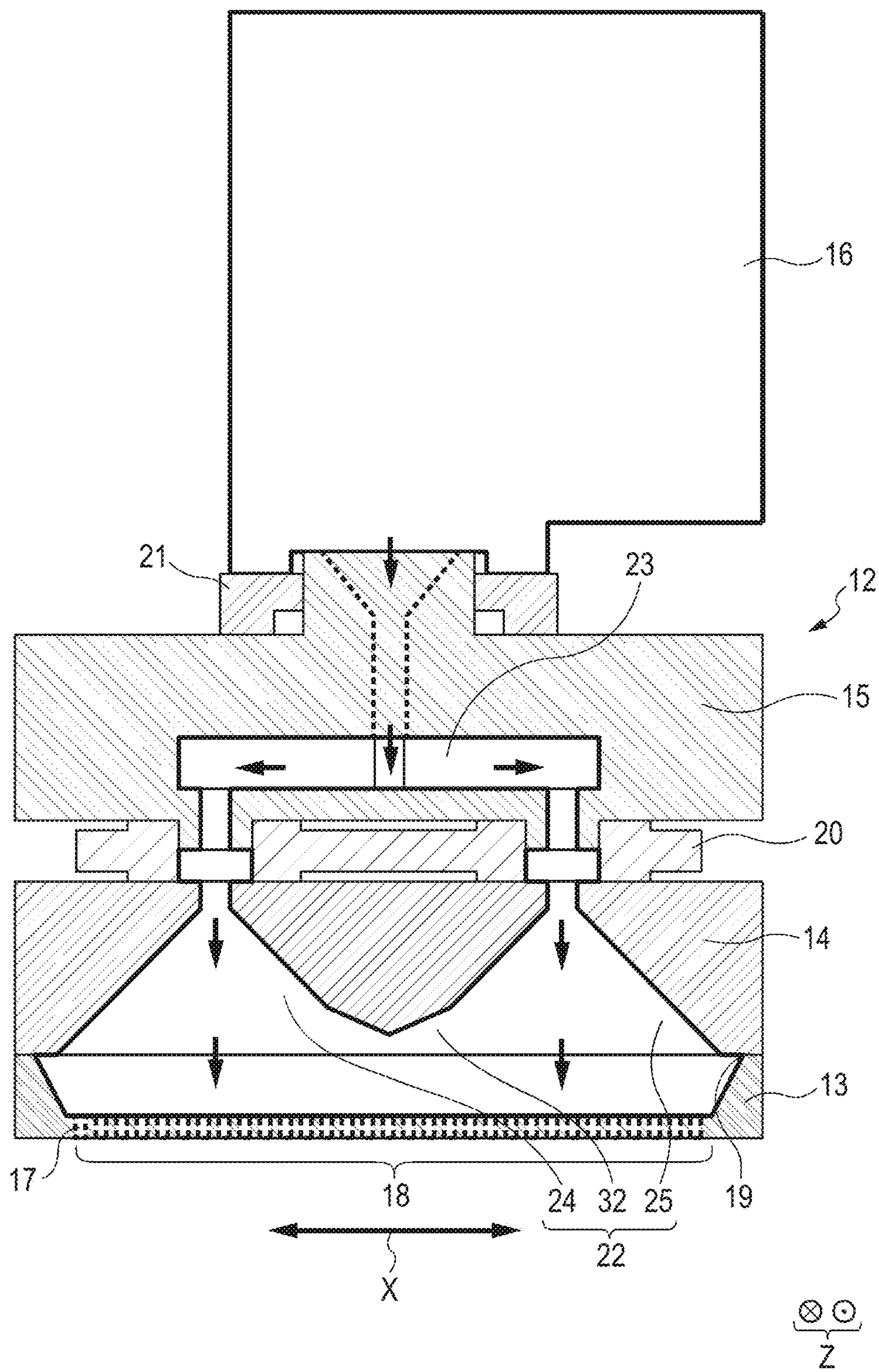


FIG. 6

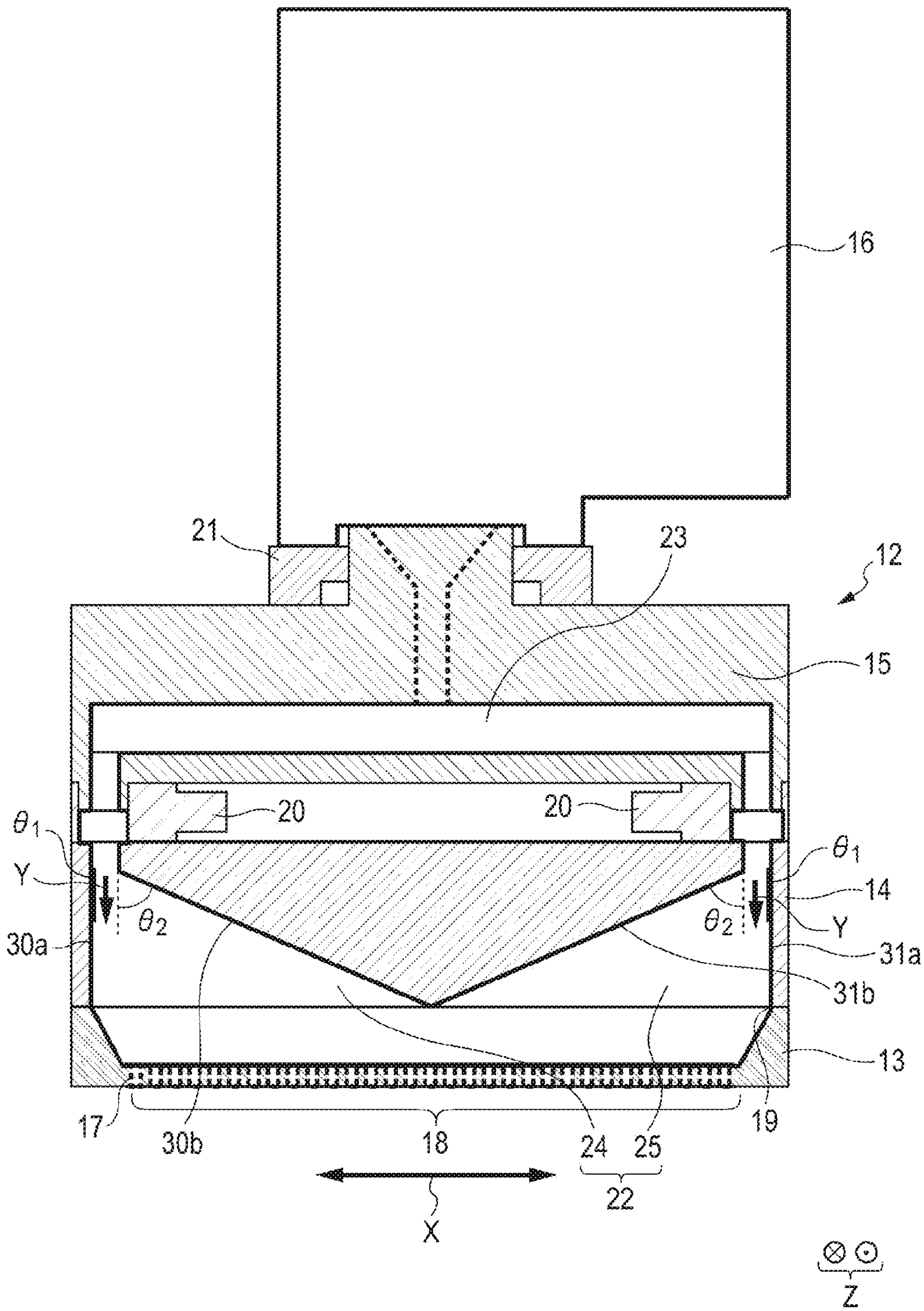

16
21
23
12
15
20
20
θ_1
θ_1
Y
14
θ_2
θ_2
Y
30a
31a
31b
13
17
30b
18
24
25
19
22
X
Z

FIG. 7

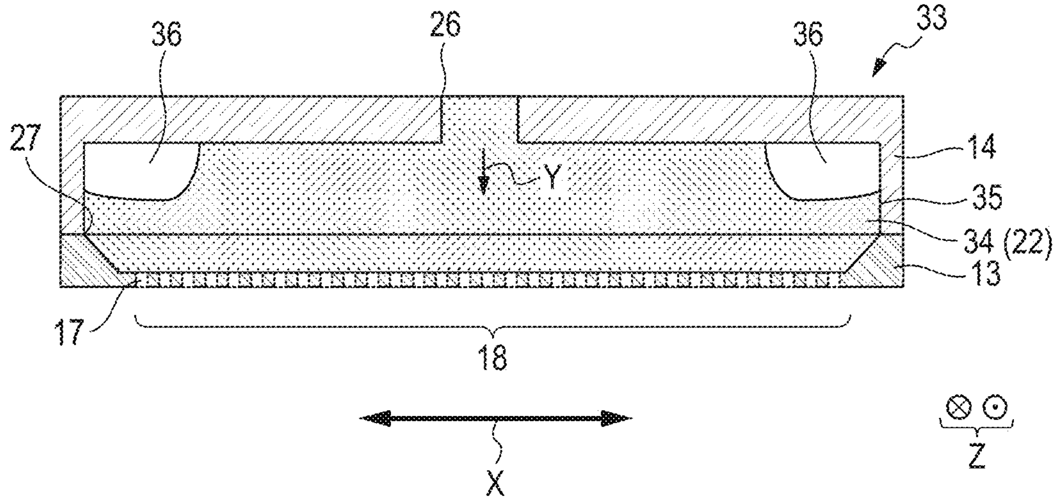

36
26
36
33
27
Y
14
35
34 (22)
13
17
18
X
Z

FIG. 8

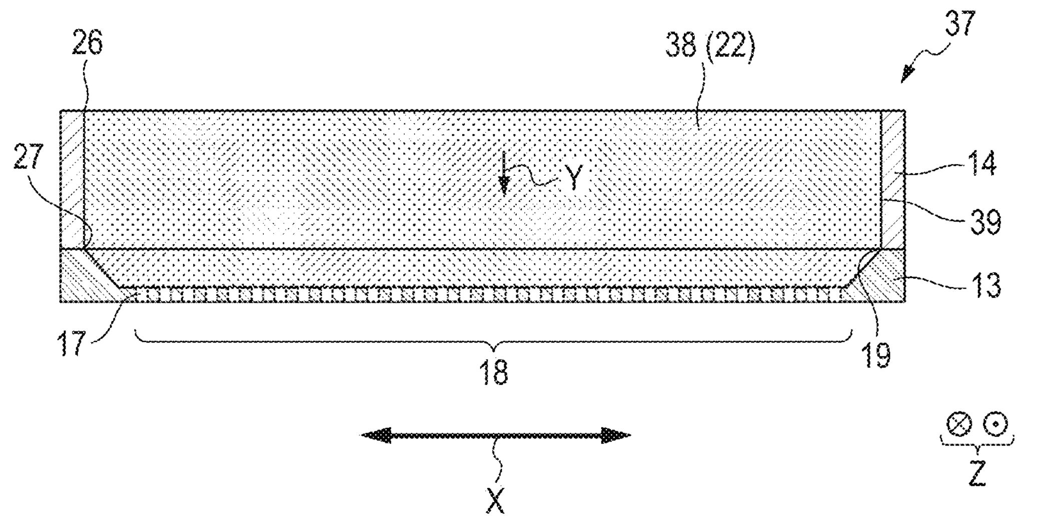

26
38 (22)
37
27
Y
14
39
13
17
18
19
X
Z

FIG. 9

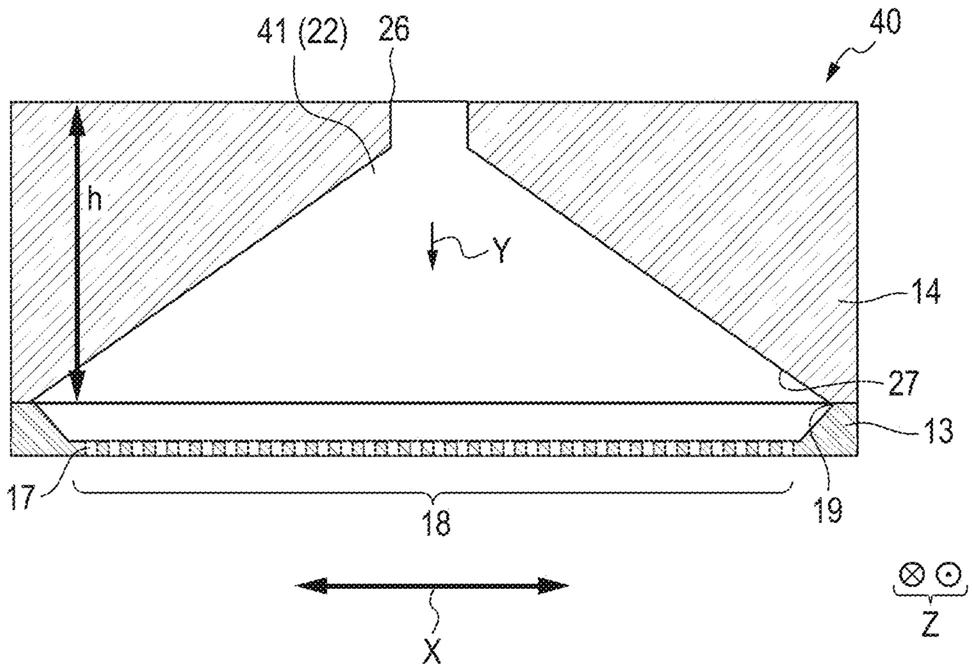
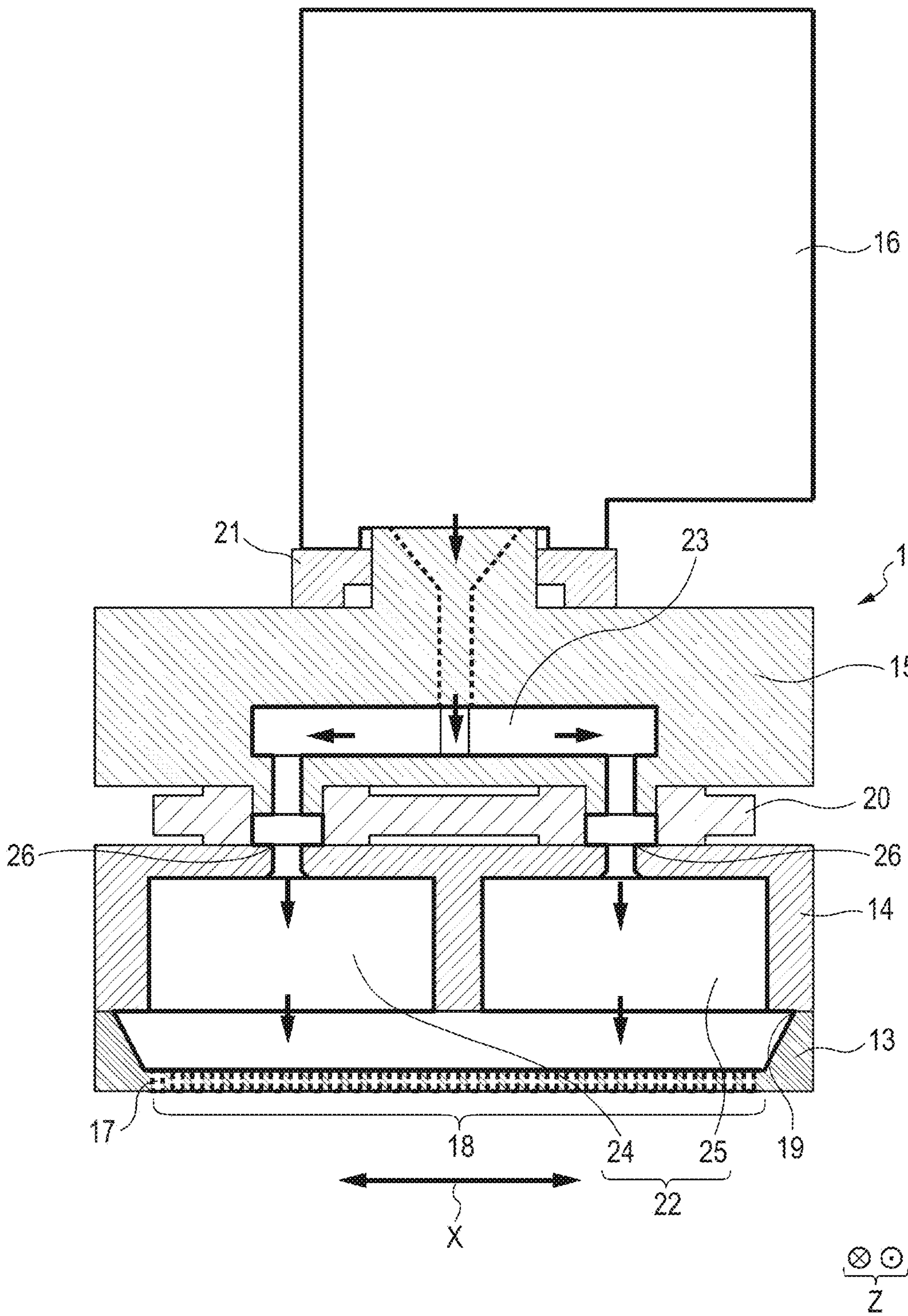
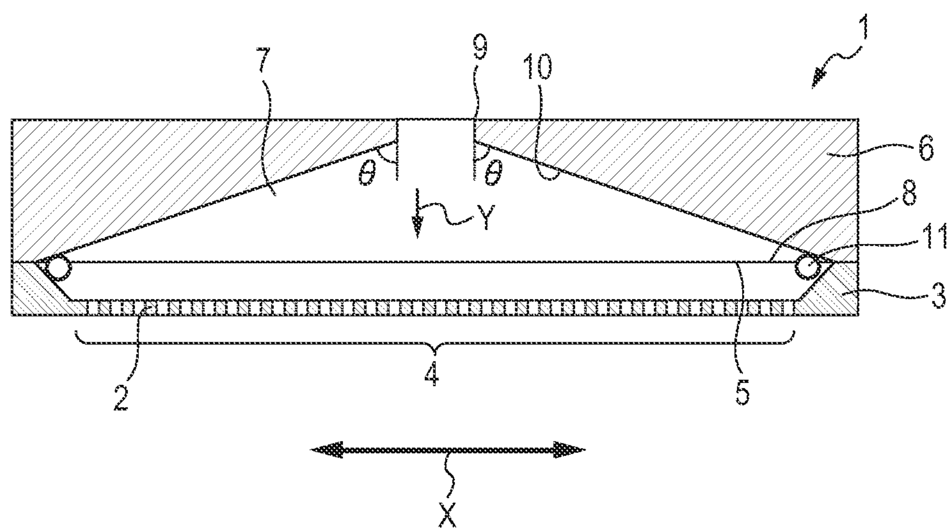


FIG. 10



Prior Art

FIG. 11



LIQUID EJECTION HEAD WITH PLURALITY OF CHANNELS FOR SUPPLYING LIQUID TO SUPPORT PORT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid ejection head for ejecting a liquid, and more specifically relates to a liquid ejection head having a ejection orifice row including a plurality of ejection orifices.

2. Description of the Related Art

An example of a liquid ejection head that is to be mounted in a main body of a liquid ejection apparatus is disclosed in Japanese Patent Application Laid-Open No. 2010-18027. In the liquid ejection head disclosed in Japanese Patent Application Laid-Open No. 2010-18027, an element substrate that includes a ejection orifice row constituted by a plurality of ejection orifices is supported by a support member. A flow path is formed inside the support member, and the flow path communicates with a supply port formed in the element substrate. A liquid is supplied to the ejection orifices via the flow path of the support member and the supply port of the element substrate.

In this connection, air bubbles in the flow path of the support member sometimes constitute a problem in the liquid ejection head. The air bubbles are caused by a gas that flows into a liquid receiving portion together with a liquid when filling the liquid into the liquid receiving portion, a gas that is dissolved in the liquid, or air that permeates a constituent member of the liquid ejection head. If air bubbles build up inside the flow path of the support member, the air bubbles hinder the flow of the liquid, whereby an ejection failure occurs.

As a method for suppressing the occurrence of the aforementioned kind of ejection failure, a method has been proposed that periodically sucks liquid from ejection orifices to eject air bubbles from the liquid ejection head together with the liquid. Further, in Japanese Patent Application Laid-Open No. 2010-18027, a configuration is disclosed in which a flow path of a support member is formed in a shape that is suitable for ejecting liquid and air bubbles when sucking the liquid. More specifically, the flow path of the support member is formed in a shape in which a cross section that intersects with a flow direction of a liquid increases from an upstream side to a downstream side with respect to a direction in which the liquid is supplied.

In recent years, there is a demand to lengthen a ejection orifice row for the purpose of ejecting liquid over a wider range. However, a new problem with respect to a liquid ejection head that arises accompanying lengthening of an ejection orifice row has become evident. The new problem will now be described using FIG. **11**.

FIG. **11** is a cross-sectional view that schematically illustrates the inner structure of a liquid ejection head disclosed in Japanese Patent Application Laid-Open No. 2010-18027. In a liquid ejection head **1** illustrated in FIG. **11**, a plurality of ejection orifices **2** is formed in an element substrate **3**. The ejection orifices are aligned in a predetermined direction to form an ejection orifice row **4**. In the present specification, the predetermined direction is also referred to as "arrangement direction X".

A supply port **5** is formed in the element substrate **3**, and a flow path **7** is formed in a support member **6**. Note that, in the present specification, a direction in which liquid flows in the flow path **7** is also referred to as "flow direction Y". The liquid is supplied from outside of the support member **6** to the

ejection orifices **2** via the flow path **7** and the supply port **5**. A cross section of the flow path **7** that intersects with the flow direction Y increases progressively in the flow direction Y.

If the ejection orifice row **4** has been lengthened in the arrangement direction X, the supply port **5** must also be lengthened in the arrangement direction X. Accompanying lengthening of the supply port **5**, it is desirable to enlarge, in the arrangement direction X, a connection port of the flow path **7** that is connected to the supply port **5** (hereunder, the connection port in question is referred to as "outlet **8**"). If the outlet **8** is enlarged in the arrangement direction X without changing the size of a connection port of the flow path **7** that is on the opposite side to the outlet **8** (hereunder, the connection port in question is referred to as "inlet **9**"), the length of a wall surface **10** of the flow path **7** with respect to the flow direction Y will increase, and furthermore an angle θ with respect to the flow direction Y will also increase.

The present inventors discovered that, as the length of the wall surface **10** of the flow path **7** increases, the air bubbles **11** are liable to stagnate more at ends in the arrangement direction X of the outlet **8**.

Thus, it became clear that in the liquid ejection head disclosed in Japanese Patent Application Laid-Open No. 2010-18027 there is the problem that an ejection failure that is caused by the air bubbles **11** is liable to occur in a case where the ejection orifice row **4** is lengthened and the angle θ is enlarged.

SUMMARY OF THE INVENTION

One aspect of the present invention for solving the above described problem is a liquid ejection head that includes an element substrate and a support member. The element substrate includes an ejection orifice row that includes a plurality of ejection orifices, and a supply port for supplying a liquid to the ejection orifices. The support member includes a first flow path for supplying a liquid from a liquid supply source to the supply port. The first flow path includes a plurality of channels that are aligned in an arrangement direction in which the plurality of ejection orifices of the ejection orifice row are aligned. At least one of the plurality of channels has a shape in which a cross section that intersects with a flow direction of a liquid increases from an upstream side to a downstream side with respect to a direction in which the liquid is supplied.

Another aspect of the present invention is a liquid ejection head having: an element substrate including a plurality of elements that generate energy that is utilized for ejecting a liquid, and a supply port for supplying a liquid to the plurality of elements; and a support member including a first face that supports the element substrate; wherein the support member includes a second face that is a rear face of the first face and in which are formed a first and a second opening that are arranged along a direction in which a plurality of the elements are arrayed, a first channel for supplying a liquid from the first opening to the supply port, and a second channel for supplying a liquid from the second opening to the supply port, in which an opening on the first face side of at least one channel among the first channel and the second channel is larger than an opening on the second face side.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a perspective view of a liquid ejection head to which the present invention can be applied.

FIG. **1**B is a perspective view of the liquid ejection head to which the present invention can be applied.

FIG. **1**C is a perspective view of the liquid ejection head to which the present invention can be applied.

FIG. **2** is a cross-sectional view of a liquid ejection head according to a first embodiment.

FIG. **3** is a cross-sectional view of the liquid ejection head taken along a line **3**-**3** illustrated in FIG. **2**.

FIG. **4** is a cross-sectional view of a liquid ejection head according to a second embodiment.

FIG. **5** is a cross-sectional view of a liquid ejection head according to a third embodiment.

FIG. **6** is a cross-sectional view of the liquid ejection head according to the third embodiment.

FIG. **7** is a cross-sectional view of a liquid ejection head according to Comparative Example 1.

FIG. **8** is a cross-sectional view of a liquid ejection head according to Comparative Example 2.

FIG. **9** is a cross-sectional view of a liquid ejection head according to Comparative Example 3.

FIG. **10** is a cross-sectional view of a liquid ejection head according to a fifth embodiment.

FIG. **11** is a cross-sectional view of a liquid ejection head relating to the present invention.

DESCRIPTION OF THE EMBODIMENTS

Embodiments for carrying out the present invention will now be described with reference to the drawings. FIGS. **1**A, **1**B and **1**C are perspective views of a liquid ejection head to which the present invention can be applied. A liquid ejection head **12** illustrated in FIGS. **1**A, **1**B and **1**C is mounted in the main body of a liquid ejection apparatus (not shown). The present invention is not limited to a liquid ejection head that is detachably attachable to the main body of a liquid ejection apparatus, and the present invention can also be applied to a liquid ejection head that is fixed in the main body of a liquid ejection apparatus.

The liquid ejection head **12** includes an element substrate **13**, a support member **14** that supports the element substrate **13**, and a flow path member **15** that is fixed to the support member **14**. The flow path member **15** is formed to be capable of holding cartridges **16***a*, **16***b* and **16***c* as liquid supply sources, and is also referred to as a "cartridge holder". Different types of liquid are contained in the cartridges **16***a*, **16***b* and **16***c*, respectively. For example, cyan ink is contained in the cartridge **16***a*, yellow ink is contained in the cartridge **16***b*, and magenta ink is contained in the cartridge **16***c*. Note that, in the present specification, the cartridges **16***a*, **16***b* and **16***c* may sometimes be referred to as "cartridge" **16** without distinguishing between the respective cartridges.

The element substrate **13** includes a plurality of ejection orifice rows **18** each including a plurality of ejection orifices **17** that are aligned in an arrangement direction X. The plurality of ejection orifice rows **18** are aligned along the arrangement direction X and a direction (also referred to as "scanning direction Z") that intersects with a direction in which liquid is ejected. The cartridges **16***a*, **16***b* and **16***c* communicate with the ejection orifices **17** of the corresponding ejection orifice rows **18**, and liquid is supplied to each ejection orifice **17** of the element substrate **13** from the cartridges **16***a*, **16***b* and **16***c*. An energy generating element (not shown) is provided in the vicinity of each ejection orifice **17**. Liquid is ejected from the respective ejection orifices **17** as a result of the energy generating element imparting an ejection energy to the liquid.

The liquid ejection head **12** that is mounted in the main body of the liquid ejection apparatus drives the energy generating elements in accordance with a signal from the main body of the liquid ejection apparatus while scanning in the scanning direction Z. By ejecting ink in a desired pattern from the respective ejection orifices **17**, a desired image is recorded on a recording medium such as paper.

The main body of the liquid ejection apparatus includes a suction unit (not shown) that sucks out liquid and air bubbles that are inside the liquid ejection head **12** from the ejection orifices **17**. By driving the suction unit, foreign matter adhered to the ejection orifices **17** and air bubbles inside the liquid ejection head **12** are removed, and an ejection failure of the liquid ejection head **12** is eliminated. The suction unit also functions as a filling unit that fills liquid into the liquid ejection head **12** when the cartridges **16**, **16***b* and **16***c* have been replaced.

Hereunder, embodiments relating to the present invention are described in further detail.

(First Embodiment)

First, a first embodiment of the present invention will be described using FIG. **2** and FIG. **3**. FIG. **2** is a cross-sectional view of the liquid ejection head **12** at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). FIG. **3** is a cross-sectional view of the liquid ejection head taken along a line **3**-**3** illustrated in FIG. **2**. Note that the flow path member **15** and the cartridge **16** are omitted from the illustration in FIG. **3**. Black arrows illustrated in FIG. **2** indicate the flow of liquid that is supplied to the ejection orifices **17** from the cartridge **16**.

As illustrated in FIG. **2** and FIG. **3**, the element substrate **13** includes a supply port **19** that supplies a liquid to the ejection orifices **17** of the respective ejection orifice rows **18**. The supply port **19** is formed in the element substrate **13** in a face thereof that is opposite to the face in which the ejection orifices **17** are formed, and a through hole is formed so as to pass through the element substrate **13** from the supply port **19** to the ejection orifices **17**. The support member **14** includes a first face **14***a* that supports a face **13***a* in which the supply port **19** is formed of the element substrate **13**. Note that the element substrate **13** is adhered to the first face **14***a* of the support member **14** using an adhesive.

A rubber member (also referred to as a "joint rubber") **20** is disposed on a second face **14***b* of the support member **14**. The second face **14***b* is located on the opposite side to the first face **14***a*. The flow path member **15** is fixed to the support member **14** through the rubber member **20**. The cartridge **16** is held in the flow path member **15** via a cartridge seal rubber **21**.

Liquid contained in the cartridge **16** is supplied to the supply port **19** through the inside of the flow path member **15**, rubber member **20** and support member **14**. The support member **14** includes a first flow path **22** that supplies liquid to the supply port. The flow path member **15** includes a second flow path **23** that supplies liquid to the first flow path **22** from the cartridge **16**. The rubber member **20** functions as a seal member that prevents the outflow of liquid from a gap between the support member **14** and the flow path member **15**. The cartridge seal rubber **21** functions as a seal member that prevents the outflow of liquid from a gap between the cartridge **16** and the flow path member **15**.

The liquid ejection head **12** also includes a first pressing unit (not shown) that presses the support member **14** towards the flow path member **15** via the rubber member **20**, and a second pressing unit (not shown) that presses the cartridge **16** towards the flow path member **15** through the cartridge seal rubber **21**. As a result of one member among the support member **14** and the cartridge holder (liquid lead-out member)

15 being pressed against the other member through the rubber member 20, it becomes more difficult for liquid to flow out from a gap between the support member 14 and the flow path member 15. Likewise, as a result of one member among the flow path member 15 and the cartridge 16 being pressed against the other member through the cartridge seal rubber 21, it becomes more difficult for liquid to flow out from a gap between the flow path member 15 and the cartridge 16.

For example, a screw can be used as the first pressing unit. For example, a spring can be used as the second pressing unit. Naturally, the first pressing unit and the second pressing unit are not limited to a screw and a spring.

The first flow path 22 will now be described. The first flow path 22 includes a plurality of channels 24 and 25 that are aligned in the arrangement direction X. The respective channels 24 and 25 extend through the inside of the support member 14 from a connection port 26 formed in the second face 14*b* of the support member 14 to a connection port 27 formed in the first face 14*a* thereof. Note that, in the present specification, to clearly distinguish between the connection port 26 and the connection port 27, in some cases the connection port 26 is referred to as "inlet" and the connection port 27 is referred to as "outlet".

The respective channels 24 and 25 communicate with the supply port 19 through the respective outlets 27. The inlets 26 of the respective channels 24 and 25 are independent from each other, and a plurality of connection ports 28 of the second flow path 23 are formed in the flow path member 15 in correspondence with the positions of the respective inlets 26. A plurality of through holes 29 are formed in the rubber member 20, and the through holes 29 connect the respective inlets 26 and connection ports 28 that correspond to each other.

The channels 24 and 25 each have a shape in which a cross section that intersects with the flow direction Y of the liquid increases from an upstream side to a downstream side with respect to the direction in which the liquid is supplied. In other words, a wall surface 30 of the channel 24 and a wall surface 31 of the channel 25 are inclined with respect to the flow direction Y. Note that the channels 24 and 25 are not limited to a smooth tapered shape. For example, a difference in level of a certain extent that does not inhibit the flow of liquid or the movement of bubbles may be formed in the wall surface 30 and wall surface 31.

In the example illustrated in FIG. 2, the shapes of the respective channels 24 and 25 are substantially symmetrical with respect to an imaginary plane that passes through the center of the ejection orifice row 18 in the arrangement direction X and intersects perpendicularly with the arrangement direction X. The present invention is not limited to this form, and the shapes of the respective channels 24 and 25 may be asymmetrical with respect to the aforementioned imaginary plane.

According to the present embodiment, since the plurality of channels 24 and 25 are aligned along the arrangement direction X, in comparison to a case where the first flow path 22 is constituted by a single channel, an angle θ of the wall surfaces 30 and 31 of each flow path 22 with respect to the flow direction Y decreases. Because the angle θ decreases, even if air bubbles arise inside the liquid ejection head 12, it is easy for the air bubbles to move to the inlet 26 without stagnating at an end in the arrangement direction X of the outlet 27. Since the inlet 26 is further than the outlet 27 from the ejection orifices 17, it is more difficult for air bubbles that moved to the inlet 26 to flow into the ejection orifices 17 in comparison with to air bubbles that have stagnated in the vicinity of the outlet 27, and therefore ejection failures are less liable to occur.

In particular, the present invention is suitable for the liquid ejection head 12 that includes the ejection orifice row 18 that was lengthened. Since the total area of the outlet 27 can be increased without increasing the angle θ, even when the supply port 19 is lengthened accompanying lengthening of the ejection orifice row 18, it is possible to efficiently feed liquid from the second flow path 23 to the supply port 19. Consequently, an adequate amount of liquid is supplied to the ejection orifices 17, and the occurrence of a state in which there is a shortage of liquid inside the liquid ejection head 12 is suppressed.

Air bubbles that have accumulated in the vicinity of the inlet 26 are removed from the ejection orifices 17 using, for example, the suction unit provided in the main body of the liquid ejection apparatus. The present invention is more suitable for a liquid ejection head that is to be mounted in a liquid ejection apparatus that includes a suction unit.

In the liquid ejection head 1 (see FIG. 11) in which the single flow path 7 is formed in the support member 14 in correspondence with the single supply port 5, if the ejection orifice row 4 is lengthened, air bubbles are liable to stagnate in the vicinity of the outlet 8. Therefore, an ejection failure arises within a relatively short time period after a liquid ejecting operation starts. In order to correct an ejection failure or prevent an ejection failure from occurring, it is necessary to perform liquid suction operations at a relatively high frequency. An increase in the frequency of performing liquid suction operations leads to an increase in the amount of waste ink, and consequently the cost of the liquid increases. Further, an increase in the frequency of liquid suction operations causes an increase in a time period in which liquid is not ejected, and therefore a time period that is required to eject a predetermined amount of liquid increases. Consequently, the benefit of enabling the ejection of liquid over a wide area that is achieved by lengthening the ejection orifice row 4 cannot be sufficiently obtained.

In the liquid ejection head 12 illustrated in FIG. 2 and FIG. 3, since it is difficult for an ejection failure to arise even if the ejection orifice row 18 is lengthened, there is no necessity to increase the frequency of liquid suction operations. Accordingly, the benefit of enabling the ejection of liquid over a wide area that is achieved by lengthening the ejection orifice row 18 is sufficiently obtained. The interval between liquid suction operations can be shorter than a period in which air bubbles that have accumulated in the vicinity of the inlet 26 grow to a size that is large enough to cause an ejection failure.

The present invention is also suitable for a thermal-type liquid ejection head that heats liquid and ejects the liquid. A liquid ejection head that uses a heater as an energy generating element may be mentioned as an example of a thermal-type liquid ejection head. In the liquid ejection head 12 of a thermal type, the number of heaters increases accompanying lengthening of the ejection orifice row 18. Consequently, the amount of generated heat of the element substrate 13 increases, and thus the temperature of liquid inside the liquid ejection head 12 is liable to rise and gas that was dissolved in the liquid is liable to form air bubbles. By utilizing the present invention in a thermal-type liquid ejection head, movement of air bubbles to the inlet 26 is facilitated. As a result, an inflow of air bubbles to the ejection orifices 17 is suppressed, and the occurrence of ejection failures can be suppressed.

In addition, according to the liquid ejection head 12 of the present invention, since it is not necessary to increase the thickness (dimension in the flow direction Y) of the support member **14**, an increase in the volume of the flow path **23** that is formed in the support member **14** can be suppressed. Since a shape that facilitates the stagnation of liquid is not formed from the inlet **26** to the outlet **27**, it is difficult for an unfilled region to be formed in the flow path **23** when filling liquid into the flow path **23**. Consequently, the amount of waste ink can be reduced when filling the flow path **23** with liquid.

As an example of specific dimensions, the length (dimension in the arrangement direction X) of the ejection orifice row **18** can be between 1 and 2 inches, the thickness (dimension in the flow direction Y) of the support member **14** can be between 3 and 5 mm, and the thickness of the element substrate **13** can be, for example, between 0.5 and 1.0 mm. Naturally, the respective dimensions of the liquid ejection head **12** according to the present invention are not limited to these dimensions.

In addition, by making the inlets **26** of the respective channels **24** and **25** mutually independent, the second face **14*b*** remains between adjacent inlets **26**, and blocking up of a gap between the support member **14** and the flow path member **15** with the rubber member **20** is facilitated. As a result, it is difficult for liquid to leak from the gap, and the reliability of the liquid ejection head **12** is enhanced. Fixing using a pressing unit such as a screw is simple in comparison to fixing using an adhesive. Accordingly, the support member **14** can be fixed to the flow path member **15** for a lower cost, and it is thus possible to suppress an increase in the manufacturing cost of the liquid ejection head **12**.

(Second Embodiment)

Next, a second embodiment of the present invention will be described using FIG. **4**. FIG. **4** is a cross-sectional view of the liquid ejection head **12** at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Black arrows illustrated in FIG. **4** indicate the flow of a liquid that is supplied from the cartridge **16** to the ejection orifices **17**. Hereunder, portions that are different to the structure of the first embodiment will be described in detail, and portions regarding which there is no particular description hereunder are taken to be in accordance with the structure of the first embodiment.

As illustrated in FIG. **4**, in the liquid ejection head **12** according to the present embodiment, the channel **24** among the plurality of channels **24** and **25** has a shape in which a cross section that intersects with the flow direction Y of the liquid increases from an upstream side to a downstream side with respect to the direction in which the liquid is supplied. The other channel **25** among the plurality of channels **24** and **25** has a shape in which a cross section that intersects with the flow direction Y of the liquid is constant from the upstream side to the downstream side with respect to the direction in which the liquid is supplied. Thus, in the present invention at least one of the plurality of channels **24** and **25** can have a shape in which a cross section that intersects with the flow direction Y of the liquid increases from an upstream side to a downstream side with respect to the direction in which the liquid is supplied.

(Third Embodiment)

Next, a third embodiment of the present invention will be described using FIG. **5**. FIG. **5** is a cross-sectional view of the liquid ejection head **12** at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Black arrows illustrated in FIG. **5** indicate the flow of a liquid that is supplied from the cartridge **16** to the ejection orifices **17**. Hereunder, portions that are different to the structure of the first embodiment will be described in detail, and portions regarding which there is no particular description hereunder are taken to be in accordance with the structure of the first embodiment.

As illustrated in FIG. **5**, the first flow path **22** includes a common channel **32** that is formed in the support member **14** and that allows the plurality of channels **24** and **25** to communicate with each other. The common channel **32** also communicates with the supply port **19**. In other words, the channels **24** and **25** are made common by the common channel **32** immediately before communicating with the supply port **19** of the element substrate **13**. According to the present embodiment, liquid can move between the plurality of channels **24** and **25**, and thus feeding of liquid to the supply port **19** is facilitated.

(Fourth Embodiment)

Next, a fourth embodiment of the present invention will be described using FIG. **6**. FIG. **6** is a cross-sectional view of the liquid ejection head **12** at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Black arrows illustrated in FIG. **6** indicate the flow of a liquid that is supplied from the cartridge **16** to the ejection orifices **17**. Hereunder, portions that are different to the structure of the first embodiment will be described in detail, and portions regarding which there is no particular description hereunder are taken to be in accordance with the structure of the first embodiment.

As illustrated in FIG. **6**, wall surfaces **30*a*** and **30*b*** of the channel **24** that face each other in the arrangement direction X are inclined at different angles with respect to the flow direction Y. More specifically, when an angle formed between the wall surface **30*a*** that is located at the end side of the ejection orifice row **18** and the flow direction Y is taken as a first angle θ_1, and an angle formed between the wall surface **30*b*** that is located at a center side of the ejection orifice row **18** and the flow direction Y is taken as a second angle θ_2, the first angle θ_1 is smaller than the second angle θ_2. According to the present embodiment, it is possible to increase the effect that guides air bubbles that are liable to stagnate at the end sides of the ejection orifice row **18** to the inlet **26**. As a result, it is difficult for air bubbles to flow into the ejection orifices **17**, and it becomes more difficult for ejection failures to occur.

Note that, although in the example illustrated in FIG. **6** the first angle θ_1 is also smaller than the second angle θ_2 in the channel **25**, the first angle θ_1 may be the same as the second angle θ_2 in the channel **25**. The first angle θ_1 can be smaller than the second angle θ_2 in at least one channel among the plurality of channels **24** and **25**.

Three embodiments of the present invention have been described above. In the embodiments described above, for each single ejection orifice row **18**, two channels **24** and **25** are formed in the support member **14**. However, according to the present invention, for each single ejection orifice row **18**, three or more channels may be formed in the support member **14**. Furthermore, naturally the present invention is also applicable to a line head-type liquid ejection head in which a plurality of the ejection orifice rows **18** are aligned in the arrangement direction X.

Examples of configurations that attempt to solve the above described problem utilizing means that are different from the present invention are described hereunder.

COMPARATIVE EXAMPLE 1

FIG. **7** is a cross-sectional view of a liquid ejection head according to Comparative Example 1 at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Note that the flow path member **15** and the cartridge **16** are omitted from the illustration in FIG. **7**. In a liquid ejection head **33** illustrated in FIG. **7**, the first flow path **22** includes a single channel **34** for a single ejection port row **18**. A cross section that intersects with the flow direction Y of the channel **34** is the same size as the inlet **26** from the position of the inlet **26** until a position that is a predetermined distance further than the position of the inlet **26** in the flow direction Y, and at the position that is a predetermined distance further than the position of the inlet **26** the cross section changes to a size that is the same as the size of the outlet **27**. In other words, a wall surface **35** of the channel **34** is parallel to the flow direction Y. In the liquid ejection head **33** according to Comparative Example 1, because the wall surface **35** of the channel **34** is parallel to the flow direction Y, it is difficult for air bubbles to stagnate at the outlet **27**.

However, in the liquid ejection head **33** according to Comparative Example 1, it is difficult for the first flow path **22** to be filled with liquid. More specifically, when liquid is being filled into the first flow path **22**, unfilled regions **36** are liable to be formed in the first flow path **22**. The unfilled regions **36** become large air bubbles at the time of a liquid ejecting operation, and ride on the flow of liquid that arises in the first flow path **22** and move to the supply port **19**. When the air bubbles block up the supply port **19**, the supply of liquid to the ejection orifices **17** is obstructed and a ejection failure occurs. If a long time is taken to perform a liquid filling operation in order to ensure unfilled regions **36** are not formed in the first flow path **22**, the amount of waste ink will increase.

COMPARATIVE EXAMPLE 2

FIG. **8** is a cross-sectional view of a liquid ejection head according to Comparative Example 2 at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Note that the flow path member **15** and the cartridge **16** are omitted from the illustration in FIG. **8**. In a liquid ejection head **37** illustrated in FIG. **8**, the first flow path **22** includes a single channel **38** for a single ejection orifice row **18**. The inlet **26** of the channel **38** is made the same size as the outlet **27** so as to prevent the formation of unfilled regions **36** that are a problem in Comparative Example 1 (see FIG. **7**). In other words, the channel **38** has a shape in which a cross section that intersects with the flow direction Y of the liquid is constant from the upstream side to the downstream side with respect to the direction in which the liquid is supplied, and a wall surface **39** of the channel **38** is parallel to the flow direction Y.

In the liquid ejection head **37** according to the present comparative example, since the wall surface **39** of the channel **38** is parallel to the flow direction Y, it is difficult for air bubbles to stagnate at the outlet **27**. Further, since the cross section that intersects with the flow direction Y of the channel **38** is constant with respect to the flow direction Y, it is easy for the channel **38** to be filled with liquid.

However, in the liquid ejection head **37** according to Comparative Example 2, the inlet **26** is relatively large and it is therefore difficult to block up the gap between the support member **14** and the flow path member **15** (see FIG. **2**) with the rubber member **20** (see FIG. **2**).

In order to manufacture the liquid ejection head **37** at a low cost, it is desirable to fix the flow path member **15** (see FIG. **2**) to the support member **14** through the rubber member **20** (see FIG. **2**). However, in the liquid ejection head **37** according to Comparative Example 2, the inlet **26** extends in the arrangement direction X. Accordingly, a portion of the rubber member **20** that is positioned between adjacent inlets **26** with respect to the scanning direction Z will have a long and narrow shape. Consequently, the rubber member **20** will not be able to adequately seal an area between adjacent inlets **26** in the scanning direction Z.

Although an area between adjacent inlets **26** can be adequately sealed with the rubber member **20** (see FIG. **2**) if the distance between the adjacent inlets **26** in the scanning direction Z is increased, in such case the size of the support member **14** and the element substrate **13** will increase. As a result, the manufacturing cost of the liquid ejection head **37** will significantly increase, which is not desirable.

In the case of fixing the flow path member **15** (see FIG. **2**) to the support member **14** using an adhesive, it is necessary to perform a process of coating an adhesive on at least one of the flow path member **15** and the support member **14**, and therefore the manufacturing cost of the liquid ejection head **37** will increase. Furthermore, if an interval between adjacent inlets **26** in the scanning direction Z is narrow, a region on which the adhesive is coated will be a long and narrow shape, and it will be difficult to apply an adequate amount of adhesive. Therefore, even when the flow path member **15** is fixed to the support member **14** using an adhesive, a failure whereby a leaking channel arises locally between the inlets **26** is easily caused.

COMPARATIVE EXAMPLE 3

FIG. **9** is a cross-sectional view of a liquid ejection head according to Comparative Example 3 at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Note that the flow path member **15** and the cartridge **16** are omitted from the illustration in FIG. **9**. In a liquid ejection head **40** illustrated in FIG. **9**, the first flow path **22** includes a single channel **41** for a single ejection orifice row **18**. Further, a thickness h (dimension in the flow direction Y) of the support member **14** is thicker than the thickness of the support member **14** according to Comparative Examples 1 and 2. According to the liquid ejection head **40** of Comparative Example 3, the outlet **27** is expanded without increasing the size of the inlet **26** and the angle θ of the channel **41**.

However, in the liquid ejection head **40**, an increase in manufacturing cost that is caused by an increase in the thickness of the support member **14** is a problem. More specifically, the support member **14** is a component that supports the element substrate **13**, and it is necessary to manufacture the support member **14** with a relatively high degree of dimensional accuracy. An increase in the thickness of the support member **14** results in a decrease in the formability of the support member **14**, and therefore more expensive manufacturing equipment is required and the manufacturing manhours that are required to manufacture the support member **14** increase. As a result, the manufacturing cost of the liquid ejection head **40** increases. In addition, the volume of the first flow path **22** increases accompanying the increase in the thickness of the support member **14**. Consequently, more time is required for the first flow path **22** to be filled with liquid, and the amount of waste ink increases.

The problems that arise in Comparative Examples 1 to 3, namely, an increase in the amount of waste ink when filling liquid, an increase in the manufacturing cost of the liquid ejection head, and a decrease in the sealing properties between the support member **14** and the flow path member **15** are not liable to arise in the case of the liquid ejection head **12** (see FIGS. **2** to **5**) according to the present invention. Accordingly, the present invention is superior to Comparative Examples 1 to 3 in terms of function, cost and reliability.

(Fifth Embodiment)

Next, a fifth embodiment of the present invention will be described using FIG. **10**. In the respective embodiments described above, structures are described in which wall surfaces of the respective flow paths are inclined faces that are inclined at an angle θ. However, the present invention is not limited thereto, and is also applicable to a form that is illustrated in FIG. **10**.

FIG. **10** is a cross-sectional view of the liquid ejection head **12** at a plane that intersects with the scanning direction Z (see FIGS. **1**A to **1**C). Black arrows illustrated in FIG. **10** indicate the flow of a liquid that is supplied from the cartridge **16** to the ejection orifices **17**. Hereunder, portions that are different to the structure of the first embodiment will be described in detail, and portions regarding which there is no particular description hereunder are taken to be in accordance with the structure of the first embodiment.

As illustrated in FIG. **10**, the first flow path **22** is formed in the support member **14** and includes the plurality of channels **24** and **25**. The ceiling surface of the flow path in the respective channels **24** and **25** is not an inclined face, and includes a face arranged along a contact surface between the support member **14** and the element substrate **13**. In this structure also, even if the element substrate is lengthened in the X direction, since the liquid ejection head **12** has a plurality of connection ports **26** and also a plurality of channels, the length of the wall surface of a ceiling portion in each channel (flow path) can be made relatively short. Hence, in comparison to a case where there is a single connection port and a single flow path, the occurrence of a state in which air bubbles stagnate in the flow path in the support member can be suppressed.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2014-034146, filed Feb. 25, 2014, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A liquid ejection head, comprising:

an element substrate including an ejection orifice row comprising a plurality of ejection orifices, and a supply port for supplying a liquid to the ejection orifices; and

a support member comprising a first flow path for supplying a liquid from a liquid supply source to the supply port, wherein:

the first flow path includes a plurality of channels for supplying a liquid to the supply port, the plurality of channels aligned in an arrangement direction in which the plurality of ejection orifices of the ejection orifice row are aligned, and

at least one of the plurality of channels has a shape in which a cross section that intersects with a flow direction of a liquid increases from an upstream side to a downstream side with respect to a direction in which the liquid is supplied.

2. The liquid ejection head according to claim **1**, further comprising:

a flow path member comprising a second flow path for supplying a liquid from the liquid supply source to the first flow path,

wherein the plurality of channels of the first flow path are connected to the second flow path at respectively independent connection ports.

3. The liquid ejection head according to claim **1**, further comprising:

a rubber member that is disposed between the support member and the flow path member and in which a through hole is formed that allows the first flow path and the second flow path to communicate with each other;

wherein one member among the support member and the flow path member is pressed against the other member through the rubber member.

4. The liquid ejection head according to claim **1**, wherein:

the first flow path further comprises a common channel that allows the plurality of channels to communicate with each other; and

the common channel communicates with the supply port.

5. The liquid ejection head according to claim **1**, wherein, in at least one of the plurality of channels, a first angle with respect to the flow direction of a wall surface that is located at an end side of the ejection orifice row is smaller than a second angle with respect to the flow direction of a wall surface that is located at a center side of the ejection orifice row.

6. The liquid ejection head according to claim **1**, wherein the liquid ejection head is a thermal-type liquid ejection head.

7. A liquid ejection head, comprising:

an element substrate comprising a plurality of elements that generate energy that is utilized for ejecting a liquid, and a supply port for supplying a liquid to the plurality of elements; and

a support member comprising a first face that supports the element substrate,

wherein the support member comprises a second face that is a rear face of the first face and in which are formed a first and a second opening that are arranged along a direction in which a plurality of the elements are arrayed, a first channel for supplying a liquid from the first opening to the supply port, and a second channel for supplying a liquid from the second opening to the supply port, in which an opening on the first face side of at least one channel among the first and second channels is larger than an opening on the second face side.

8. The liquid ejection head according to claim **7**, wherein:

the support member comprises a common channel which allows the first channel and the second channel to communicate with each other, and

the common channel communicates with the supply port.

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